TECHNICAL REPORT
NATICK/TR-17/015

AD _____

CORRELATION OF AATCC TEST METHOD 150 TO AATCC TEST METHOD 61 FOR USE WITH LAUNDERING DURABILITY STUDIES OF RETROREFLECTIVE ITEMS AS DEFINED IN PURCHASE DESCRIPTION CO/PD-06-05A

by
Megan L. Hoey
and
Denise M. Tolliver

June 2017

Final Report
October 2014 – April 2016

Approved for public release; distribution is unlimited

U.S. Army Natick Soldier Research, Development and Engineering Center
Natick, Massachusetts 01760-5000

DISCLAIMERS

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

DESTRUCTION NOTICE

For Classified Documents:

Follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For Unclassified/Limited Distribution Documents:

Destroy by any method that prevents disclosure of contents or reconstruction of the document.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
02-06-2017	Final	October 2014 – April 2016

4. TITLE AND SUBTITLE

CORRELATION OF AATCC TEST METHOD 150 TO AATCC TEST METHOD 61 FOR USE WITH LAUNDERING DURABILITY STUDIES OF RETROREFLECTIVE ITEMS AS DEFINED IN PURCHASE DESCRIPTION CO/PD-06-05A

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Megan L. Hoey and Denise M. Tolliver

5d. PROJECT NUMBER
14-156

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Natick Soldier Research, Development and Engineering Center
ATTN: RDNS-TMF
10 General Greene Avenue, Natick, MA 01760-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

NATICK/TR-17/015

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This report contains laundering test data to the support the correlation between 5 laundering cycles of the America Association of Textile Chemists & Colorists Test Method 61 "Colorfastness to Laundering, Home and Commercial: Accelerated" to 25 laundering cycles of the America Association of Textile Chemists & Colorists Test Method 150 "Dimensional Change of Garments after Home Laundering". The U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) endorsed this work under the Warfighter Improved Combat Identification Development project to explore the opportunity for reducing laundering test time and laundering test cost for the launderability testing of the ¾ inch Identification of Friend or Foe (IFF) patch that is sewn to the uniform. Through several trials the appropriate test parameters were identified to yield the same level of degradation, identified by visual examination, for samples that underwent 5 laundering cycles of AATCC 61 and 25 cycles of AATCC 150.

15. SUBJECT TERMS

TIME	SHRINKAGE	COLORFASTNESS	DEFECTS(MATERIALS)	PERFORMANCE TESTS
COSTS	TOLERANCE	DEGRADATION	QUALITY CONTROL	VISUAL EXAMINATION
FABRICS	VARIATIONS	TEST METHODS	WEAR RESISTANCE	ENDURANCE(GENERAL)
PATCHES	DURABILITY	REQUIREMENTS	VISUAL INSPECTION	LAUNDRY OPERATIONS
TEXTILES	STANDARDS	ACCEPTABILITY	LABORATORY TESTS	TEST AND EVALUATION
UNIFORMS	DEFICIENCIES	SPECIFICATIONS	PERFORMANCE(ENGINEERING)	PARAMETERS
SAMPLING	CORRELATION	DETERIORATION	LIFE EXPECTANCY(SERVICE LIFE)	

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Megan Hoey
U	U	U	UU	40	**19b. TELEPHONE NUMBER** *(include area code)* (508) 233-6421

This page intentionally left blank

Table of Contents

List of Figures

List of Tables

Preface

Identification of Friend or Foe (IFF) is an important capability for the Solider in the field. One of the current IFF capabilities utilized by Soldiers is a ¾ inch square retroreflective patch, two of which are sewn to the Army Combat Uniform (ACU) Coat (one on each shoulder) and three of which are sewn to the ACU Helmet Cover. The purchase description Patch and Brassard, Identification, Infrared Retroreflective (CO/PD-06-05A) covers the requirements for identification patches and brassards made of infrared (IR) retroreflective material for use with combat clothing, equipment, and vehicles. The IR item of interest herein is the ¾ inch square patch, sewn on application (referred to in the purchase description as Type 1). The purchase description requires evaluation of the surface characteristics, visual appearance, and retroreflective performance of the ¾ inch square patch before and after 25 laundering cycles as outlined in the America Association of Textile Chemists & Colorists (AATCC) Test Method 150 "Dimensional Changes of Garments after Home Laundering". Performing 25 laundering cycles of a large swatch of fabric on which 5 patches are sewn is both time consuming and costly. There are other laundering test methods that utilize various techniques (e.g., smaller swatch sizes, more aggressive cycle conditions) to simulate the exposure of multiple cycles within a single wash cycle. One such test method is AATCC 61 "Colorfastness to Laundering, Home & Commercial: Accelerated". Identifying a method by which the number of wash cycles required is reduced while still gaining useful correlated information about sample durability will save time as well as cost in the process of material and sample down selection.

The study performed in this report was carried out in order to correlate the laundering test parameters for AATCC 61 to AATCC 150 as a means to achieve the same degradation as 25 launderings in only 5 wash cycles. When researchers are evaluating new materials, they are required to assess the durability via AATCC 150 per the purchase description to ensure the new material will at least match the legacy/current material. When there are several samples to be evaluated, the time associated with 25 laundering cycles and the cost associated with a large swatch of fabric become cumbersome. Utilizing a correlated AATCC 61 method would enable researchers to decrease run time by up to 80% and reduce fabric waste from several square feet to a few square inches. This correlation allows the determination of changes in the surface characteristics, visual appearance, and retroreflective performance of the patches to be examined after five wash cycles; this will decrease both test run time and costs. This study was designed and conducted from October 2014 to April 2016 by United States Army researchers, working at the Natick Solider Research Development and Engineering Center (NSRDEC) in Natick, Massachusetts under the internal funding of the Warfighter Improved Combat Identification Development (WICID) effort.

Acknowledgements

The authors would like to thank several groups for their contributions to this report: the NSRDEC Fiber & Textile Science Team members for their continued support, the NSRDEC Textile Material Evaluation Team member Susan Gasset for providing her textile technology expertise and for executing all of the developmental laundering tests, NSRDEC Personal Protective Equipment Team members for their ongoing support, and the Navy Clothing Textile Research Facility, Defense Logistics Agency-Product Test Center (DLA-PTC) and Precision Testing Laboratories for executing the finalized correlated testing parameters in order to validate the findings from testing performed at Natick.

CORRELATION OF AATCC TEST METHOD 150 TO AATCC TEST METHOD 61 FOR USE WITH LAUNDERING DURABILITY STUDIES OF RETROREFLECTIVE ITEMS AS DEFINED IN PURCHASE DESCRIPTION CO/PD-06-05A

1.0 Introduction

Work for this report was performed from October 2014 to April 2016 by the Natick Soldier Research, Development and Engineering Center (NSRDEC), with the goal of reducing test cost and run time for durability standards of infrared retroreflective patches. This report focuses specifically on the laundering and durability of the ¾ inch square Identification of Friend or Foe (IFF) retroreflective patch.

The purchase description CO/PD-06-05A Patch and Brassard, Identification, Infrared Retroreflective, dated 10 November 2011, details a specific American Association of Textile Chemists and Colorists (AATCC) laundering test method to be used to evaluate the durability of such items. The current test method, AATCC 150 Dimensional Change of Fabrics After Home Laundering, requires 25 laundering cycles before evaluation of the item(s); this method is both timely and costly. The AATCC has an accelerated laundering test method, AATCC 61, 2A Colorfastness to Laundering, Home and Commercial: Accelerated (Machine Wash), which would reduce the required laundering cycles to five and thereby reduce run time and costs associated with the durability testing. There are several parameters that can be varied within AATCC 61 in order to achieve specific laundering conditions. These parameters were explored by members of the Fiber and Textile Science Team (FTST) and Personal Protective Equipment Team (PPET) of the NSRDEC. This report details the multitude of experimental laundering tests performed in order to identify the AATCC 61 test method parameters which best correlate to the AATCC 150 home laundering test method. The importance of correlating the two methods is to ensure that the same material durability information is being derived from the 5 laundering cycles as the 25 cycles. If the results of the two methods do not match, then the accelerated method cannot replace AATCC 150.

AATCC 150 requires the ¾ inch square IFF patches be sewn to a large piece of fabric that then undergoes 25 wash cycles at specific temperatures. The changes seen in surface characteristics, visual appearance, and retroreflective performance of the patches as a result of the 25 cycles of AATCC 150 were correlated to 5 cycles of AATCC 61. It is important to ensure that the patches will maintain their structural integrity and, in turn, their performance capability through the laundering process. If the patch degrades past its threshold of operational effectiveness through the laundering cycle, it is of no use to the Soldier. The examination of the visual appearance of the patch surface allows the identification of any delamination that may have taken place during laundering. Delamination of the thin films that make up the patch will cause the retroreflective performance to diminish below a level of operational effectiveness. This study aims to identify the parameters required to assess patch durability after 5 cycles of AATCC 61 versus 25 cycles of AATCC 150. AATCC 61 offers various parameters/conditions that accelerate the results of standard home laundering. AATCC 61 is performed using small 2 inch x 6 inch sample fabric swatches that are then put in a steel canister along with steel or silicone pellets/balls and water. There are two accepted canister sizes, the number of steel and or silicone pellets/balls can be varied, and the liquid volume of the water specified. These parameters, as well as procedure temperature, were explored extensively to identify the set of parameters that best represented the same changes seen in surface characteristics, visual appearance, and retroreflective performance of the patches as a result of the 25 cycles of AATCC 150. The first task outlined in this report focuses on the current purchase description

laundering test method AATCC 150. It was important to establish strong baselines utilizing this method before going on to any correlation steps. Several ¾ inch patches from two different suppliers went through 25 laundering cycles under AATCC 150 conditions. The surface characteristics realized by visual examination of these patches were used in the correlation of the samples produced in the second task. The second task of this report focuses on the accelerated laundering parameters required to generate correlated results of 25 home laundering cycles in just 5 accelerated laundering cycles. The accelerated test method used in Task II was AATCC 61. Several laundering experiments were performed while varying AATCC 61 testing parameters in order to replicate the same results as AATCC 150. In order to change the purchase description laundering requirements from 25 cycles of AATCC 150 to 5 cycles of AATCC 61, it is imperative that the ¾ inch patches exhibit the same level of degradation and durability through both processes.

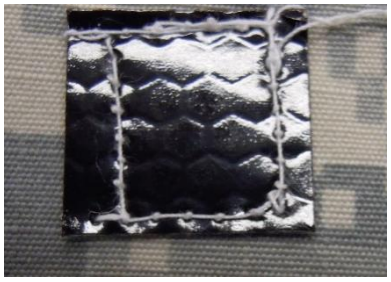
2.0 Task I – Testing, Home Laundering

2.1 Methodology

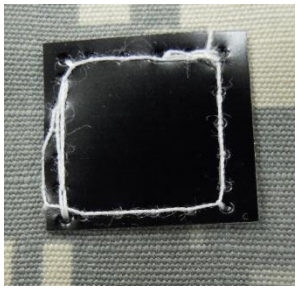
Task I employed two functions for home laundered Infrared (IR) patches. The first function subjected IR patches to 25 cycles of home laundering. This was done in accordance with the specification requirements outlined in the CO/PD-06-05A for the ¾-inch IR patches (referred to in the purchase description and throughout this report as Type I patches). The patches were tested for determination of changes in surface characteristics and visual appearance. Surface characteristics pertain to the occurrence of scratches, marring, cracks, curling, melting, flaking, and/or crazing; visual appearance pertains to ink or coating color changes or color loss. The second function established home laundered IR patch baselines with respect to surface characteristics and visual appearance utilizing AATCC 150. These baselines provided the foundation to rate IR patches laundered under home or other laundering conditions.

2.1.1 Items Evaluated

In response to the 2014 NSRDEC Market Survey posted on the Federal Business Opportunity website, two current and military approved IR patch manufacturers, CeJay Engineering and Infrared Tools, provided production-level IR Patches, herein referred to as test specimens for this laundering study. The CeJay Engineering specimens had a glossy, honeycomb textured appearance while the Infrared Tools specimens had a low gloss, smooth surface appearance. Both IR patches are shown in Figure 1. Test specimens from each company were randomly selected and then prepared and home laundered in accordance with AATCC 150 as stated in the CO/PD-06-05A.



CeJay Engineering Patch



Infrared Tools Patch

Figure 1. Test specimen, initial surface appearance

2.1.2 Specimen Preparation

Type I, ¾-inch IR patches are permanently sewn to military end items such as the Army Combat Uniform (ACU) Coat and the Advanced Combat Helmet (ACH) Cover. During operational use, the attached IR patches are laundered under the same conditions as the end items. To simulate home laundering of end items and to ensure testing consistency for the IR patches, test specimens were prepared in accordance with CO/PD-06-05A specification verification sections paragraphs 4.6.3, 4.6.3.1, 4.6.3.2, and 4.6.4 (see Appendix A). Five test specimens were box stitched to a cloth panel as shown in Figures 2 and 3.

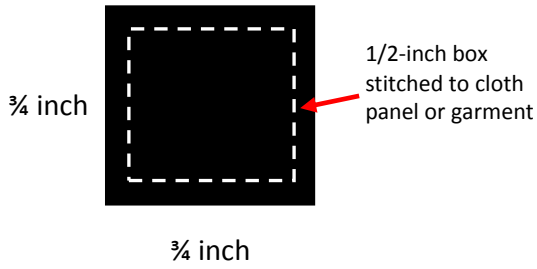


Figure 2. IR patch with stitching guidelines

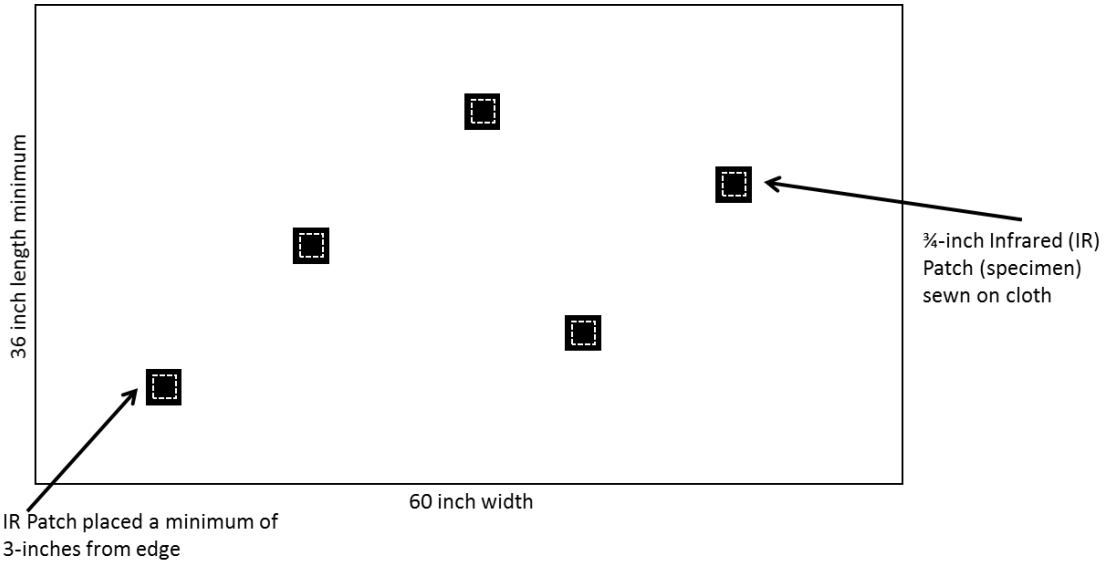
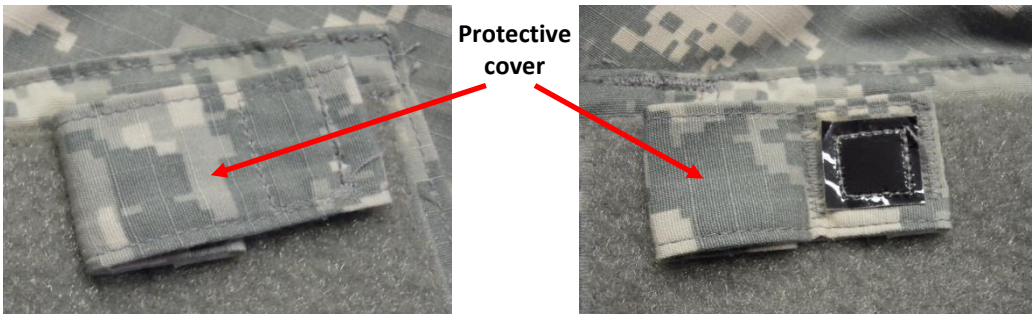


Figure 3. Home laundering – Cloth panel with five IR patches (test specimens)

The specification requires a large woven cloth panel approximately 60 inches wide by 36 inches long with a minimum cloth weight of 6 oz per square yard to simulate a typical military end item and provide adequate agitation during the laundering and drying cycles. The specimens were box stitched to the cloth panel without a cloth or webbing protective cover, which is normally present during laundering on military end items in the field. This set-up replicated a worst case scenario when the IR patch is left unprotected during operational use or laundering. When test specimens perform satisfactorily and maintain integrity under worst case scenarios, then the product will perform well under normal laundering conditions. Figure 4, shown below, illustrates the standard cloth protective cover that is normally present.



With protective cover Protective cover turned back

Figure 4. IR patch with protective cover in use and protective cover turned back

2.1.3 Test Procedures

A total of 15 specimens were home laundered and evaluated. Each of the two manufacturers, CeJay Engineering and Infrared Tools, had five randomly selected specimens designated as an independent set prepared for laundering. The two sets were separately laundered for 25 cycles (i.e., a complete wash, rinse, and dry cycle) in accordance with required parameters in AATCC 150, the laundering specification used by CO/PD-06-05A. The test conditions for this study are shown in Table 1. Using a water temperature of 140 °F, which is designated "very hot" by AATCC, represents the worst case exposure when cleaning heavily soiled garments or garments laundered in Military operational environments.

Table 1. Home laundering test conditions

Machine Type	Machine Cycle Type	Machine Load Weight (lb)	Wash Temp	Rinse Temp	Dryer Setting
Top load washer	Permanent press	4 lb; cloth panel with sewn specimens plus ballast	140 °F	80 °F	Permanent press

A third set of home laundering tests were performed using low gloss, smooth surface specimens from Infrared Tools. This company was selected to provide additional specimens because 100 ACU coats received from theater and inspected at NSRDEC represented the low gloss, smooth surface IR patches seen on military end-items rather than the honeycomb pattern observed on CeJay Engineering IR patches.

2.1.4 Specimen Observation Procedures

The CO/PD-06-05A provides IR patch surface characteristics and visual appearance requirements. These can be found in the purchase description in notes 4, 6, and 7 listed under Table 1 titled "Physical requirements of end item". The criteria for surface characteristics and visual appearance referenced in the notes of the purchase description are listed here in Table 2.

Table 2. IR patch surface characteristics and visual appearance

Surface characteristics	Scratch
	Marring
	Cracks
	Curling
	Melting
	Flaking
	Crazing
Visual appearance	Color Change – Ink or coating
	Color Loss – Ink or coating

The specification requirements are stated in absolute performance terms such as "shall not crack, melt, lose color…" or "shall be no cracking, crazing or flaking of inks…"[1]. In addition, the specification does not provide criteria for rating specimens or specimen lots that encountered minimal degradation of surface characteristics and visual appearance after laundering.

For this NSRDEC study, surface/visual examinations were made after the following laundering cycles (intervals): 0, 1, 2, 3, 4, 5, 8, 10, 12, 15, 20, and 25. Observations were made at these intervals rather than at the end of the 25th cycle, as indicated in the specification, to better record the occurrence of any specimen changes (see Appendix B). Without a minimum, maximum, or range criteria for the surface characteristics and visual appearance, as stated in Table 2, observations were noted when the specimen changes occurred and the details of the change were recorded in comparison to the previous observations.

2.2 Results and Discussion

At the specified home laundering intervals (Section 2.1.4) each test specimen was examined for the determination of changes in surface characteristics and visual appearance (Table 2). Starting after the first or second laundering cycle, some test specimens underwent some surface and/or visual changes when compared to a new, unlaundered specimen (see Figure 5a and 5b). Common specimen changes were bending or curling upwards to the stitch line on one or more corners. As the laundering progressed to approximately 10 cycles, the corners bent slightly more and the infrared top coating lifted from the base material on some corners (see Figure 5c). From 11 to 25 cycles, bent corners stabilized, the infrared top coating lifted from the base material on more corners and from some straight edges up to the stitch line, and light creasing occurred on the specimen center (see Figure 5d).

[1] Purchase Description Patch and Brassard, Identification, Infrared Retroreflective (CO/PD-06-05A). 10 November 2011.

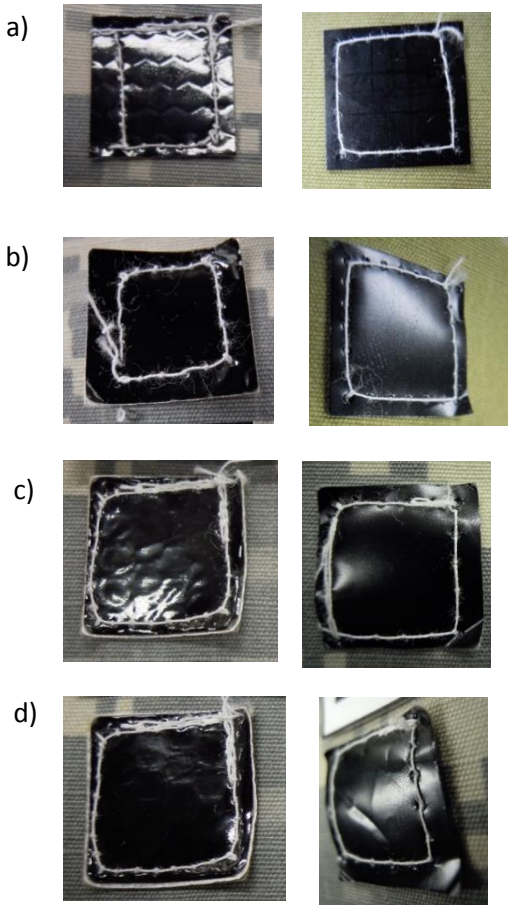


Figure 5. Home laundering: Surface characteristics and visual appearance from initial to 25 cycles. a) Unlaundered; b) after 1 home laundering cycle; c) after 10 home laundering cycles; d) after 25 home laundering cycles

After 25 home laundering cycles, no specimens from either manufacturer exhibited absolute performance in terms of no degradation to surface characteristics and/or visual appearance. Changes ranged from minimal to slightly noticeable. All specimens maintained a visual functional center area, approximately ¼ square inches (161 square mm) within the stitching line.

Home laundering findings demonstrated three common specimen changes to the surface characteristics and/or visual appearance: corners or edges curled/bent, infrared top coating lifted from the base material on corners or edges, and light creases throughout the specimen. The derived recommended baselines are listed in Table 3 and diagramed in Appendix C.

Table 3. IR patch, recommended surface characteristics and visual appearance baselines

IR Patch Characteristic	Recommended Baseline
Infrared, black top coating	Peeling or lifting off base material from corner or edge no greater than 1/16-inch (0.06).
Creasing or bending	Depth no greater than 1/16-inch (0.06) without breaking coating or exposing base material.
Curling or bending	Edges (up to the stitching line) curling or bending upwards from cloth panel or substrate no greater than 3/32-inches (0.09).

3.0 Task II – Testing, Accelerated Laundering

3.1 Methodology

The goal of Task II was to fully explore accelerated laundering test methods as a replacement for home laundering procedures cited in Purchase Description, Patch and Brassard, Identification, Infrared Retroreflective, CO/PD-06-05A for Type I, square patch, sewn-on application. The development and adoption of an accelerated laundering test method, when compared to specification home laundering procedures, would potentially reduce laundering time by approximately 80% and lower laundering cost nearly 75% when considering decrease in labor hours for sample preparation and testing as well as the decrease in fabric required by approximately 97%. AATCC Test Method 61-2013, Colorfastness to Laundering, Home & Commercial: Accelerated Test Method was used to develop accelerated laundering procedures for IR patches.

3.1.1 Items Evaluated

Only IR patches from Infrared Tools were used to develop an accelerated laundering test method. Using one manufacturer minimized test specimen differences, thus allowing experimental focus on laundering effects rather than product variability encountered then using multiple suppliers.

3.1.2 Test Specimen Preparation

Test specimen preparation of IR patches for accelerated laundering augmented and eliminated some AATCC Test Method 61-2013 set-up requirements to accommodate IR Patches and better simulate laundering of this product. The base cloth acted as a carrier for the IR patch (test specimen) rather than as an agent being assessed for colorfastness. For this reason, the specified multifiber test fabric was eliminated, because colorfastness was not being assessed. The test specimen was sewn to a woven base cloth weighing approximately 6 oz per square yard to simulate the individual cloth weight of military end-items. The base cloth test component dimensions were either 2-inch width by 4-inch length or 2-inch width by 6-inch length, as specified by the AATCC Test Method 61. The test specimen was box stitched to the upper third of the base cloth test component using the same stitching procedures as outlined in specification CO/PD-06-05A, paragraph 4.6.3.1 (see Figure 6).

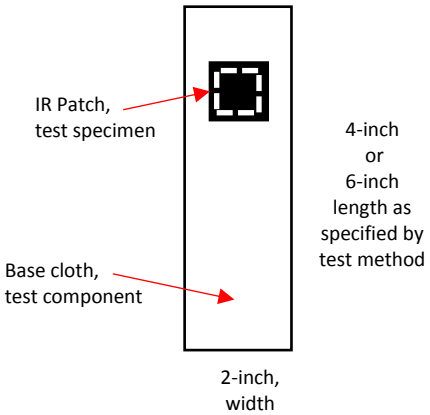


Figure 6. Accelerated laundering test specimen preparation

3.1.3 Test Procedures

Six accelerated laundering trials were conducted by NSRDEC Textile Material Evaluation Team (TMET) to establish procedures for IR patches (see Appendix D). This was done in order to determine correlation between the accelerated laundering method with home laundering surface characteristics and visual appearance test specimen baselines. The trials ranged from laundering test specimens using the same test conditions outlined in Table I of AATCC Test Method 61-2013 to formulating test procedures, which adjusted such factors as laundering temperature, liquid volume, and number of steel balls (which provide mechanical agitation). Each succeeding trial based its test procedures on results from the previous set of trials. For this study, surface/visual examinations were made prior to laundering (the initial state) and after each accelerated cycle. As outlined in AATCC Test Method 61-2013, paragraph 2.1, each accelerated laundering cycle approximates five hand or home laundering cycles.

3.1.3.1 TMET Work Order Number 14294

The first trial, TMET Work Order Number 14294, was conducted to understand the effects of surface characteristics and visual appearance on test specimens using AATCC Test Method 61-2013, Test Numbers 1A, 2A, and 3A procedures. See Table 4 for more details. These test numbers were selected because they represent typical laundering procedures for military end items. Specifically, 1A uses warm water with the lowest number of steel balls; 2A uses hot water, a medium number of steel balls, and is used to test Army Combat Shirts; and 3A uses extra hot water, the highest number of steel balls, and is used to test colorfastness of 50/50 nylon/cotton blend, wind resistant poplin rip stop cloth, which is the base material for the ACU. The full test condition table from AATCC Test Method 61-2013 can be found in Appendix E.

Table 4. Accelerated laundering – TMET Work Order Number 14294

Test number	Base cloth test component size (inches)	Laundering temperature (°F ± °4)	Laundering cycles[1]	Liquid volume (mL)	Test canister size (mL)	Number of steel balls	Oven drying temperature (°F)
1A	2 x 4	105	4	200	500 (Type 1)	10	140
2A	2 x 6	120	4	150	1200 (Type 2)	50	140
3A	2 x 6	160	4	50	1200 (Type 2)	100	140

Note: Four accelerated laundering cycles simulates 20 home laundering cycles

3.1.3.2 TMET Work Order Number 14412, Part 1

TMET Work Order Number 14412 was established to better track test procedure changes. Part I evaluated one laundering temperature against a variable number of steel balls in order to assess agitation on test specimens. The laundering temperature was set at 140 °F to correlate with home laundering of ACUs under test conditions. The number of steel balls varied from a high of 100 to a low of 10. All trials used a 2-inch by 6-inch base cloth test component and were laundered for five accelerated cycles, which simulates 25 home laundering cycles. The test procedures are outlined in Table 5.

Table 5. Accelerated laundering – TMET Work Order Number 14412, Part 1

Test number	Laundering temperature (°F ± °4)	Test canister size (mL)	Liquid volume (mL)	Number of steel balls	Oven drying temperature (°F)
A-140-100	140	1200 (Type 2)	150	100	140
A-140-50	140	1200 (Type 2)	150	50	140
A-140-25	140	1200 (Type 2)	150	25	140
A-140-10	140	1200 (Type 2)	150	10	140

3.1.3.3 TMET Work Order Number 14412, Part 2

TMET Work Order Number 14412, Part 2 enabled the evaluation of the laundering of 15 specimens that had been measured for Coefficient of Retroreflection (R_A) prior to laundering. All trials used a 2-inch by 6-inch base cloth test component and were laundered for 5 accelerated cycles, which simulates 25 home laundering cycles. The test procedures are outlined in Table 6.

Table 6. Accelerated laundering – TMET Work Order Number 14412, Part 2

Specimen Test numbers[1]	Laundering temperature (°F ± °4)	Test canister size (mL)	Liquid volume (mL)	Number of steel balls	Oven drying temperature (°F)
16-30	140	1200 (Type 2)	150	100	140

Note: The test number was marked on the base cloth test component for tracking purposes and prevention of test specimen damage

3.1.3.4 TMET Work Order Number 14412, Part 3

TMET Work Order Number 14412, Part 3 trials were conducted to evaluate four different test parameters: laundering temperature, liquid volume, number of steel balls, and drying temperature. All trials used a 2-inch by 6-inch base cloth test component and were laundered for 5 accelerated cycles, which simulates 25 home laundering cycles. The test procedures are outlined in Table 7. The TMET ID alpha character represents a set of test parameters while the numeric character represents the specimen; two test specimens were laundered for each set of parameters.

Table 7. Accelerated laundering – TMET Work Order Number 14412, Part 3

TMET ID[1]	Laundering temperature (°F ± °4)	Test canister size (mL)	Liquid volume (mL)	Number of steel balls	Oven drying temperature (°F)
A1 and A2	140	1200 (Type 2)	150	100	140
B1 and B2	140	1200 (Type 2)	150	100	120
C1 and C2	140	1200 (Type 2)	150	50	120
D1 and D2	140	1200 (Type 2)	50	100	120
E1 and E2	140	1200 (Type 2)	50	50	120
F1 and F2	120	1200 (Type 2)	150	100	120
G1 and G2[2]	120	1200 (Type 2)	150	50	120

Note 1: For each test parameter, two test specimens were laundered; they were numbered 1 and 2
Note 2: The test parameters were the same as for AATCC Test Method 61-2013 except the oven temperature was set to 120 °F

3.1.3.5 TMET Work Order Number 14412, Part 4

TMET Work Order Number 14412, Part 4 trials were conducted to assess the effect of liquid volume. All trials used a 2-inch by 6-inch base cloth test component and were laundered for 5 accelerated cycles, which simulates 25 home laundering cycles. The test procedures are outlined in Table 8.

Table 8. Accelerated laundering – TMET Work Order Number 14412, Part 4

TMET ID[1]	Laundering temperature (°F ± °4)	Test canister size (mL)	Liquid volume (mL)	Number of steel balls	Oven drying temperature (°F)
A1 and A2	120	1200 (Type 2)	50	50	120
B1 and B2	120	1200 (Type 2)	150	50	120

Note: For each test parameter, two test specimens were laundered; they were numbered 1 and 2

3.1.3.6 TMET Work Order Number 14412, Part 5

TMET Work Order Number 14412, Part 5 trials were conducted to verify the effects of liquid volume reduction to 50 mL. All trials used a 2-inch by 6-inch base cloth test component and were laundered for 5 accelerated cycles, which simulates 25 home laundering cycles. The test procedures are outlined in Table 9.

Table 9. Accelerated laundering – TMET Work Order Number 14412, Part 5

TMET ID[1]	Laundering temperature (°F ± °4)	Test canister size (mL)	Liquid volume (mL)	Number of steel balls	Oven drying temperature (°F)
“A1-Group 2” and “A2-Group 2”	120	1200 (Type 2)	50	50	120

Note: For each test parameter, two test specimens were laundered; they were numbered 1 and 2

3.1.3.7 TMET Work Order Number 14412, Part 6

TMET Work Order Number 14412, Part 6 evaluated the laundering of 10 specimens that had been tested for R_A prior to laundering. All trials used a 2-inch by 6-inch base cloth test component and were laundered for 5 accelerated cycles, which simulates 25 home laundering cycles. The test procedures are outlined in Table 10.

Table 10. Accelerated laundering – TMET Work Order Number 14412, Part 6

Specimen Test numbers[1]	Laundering temperature (°F ± °4)	Test canister size (mL)	Liquid volume (mL)	Number of steel balls	Oven drying temperature (°F)
2, 4, 5, 7, 8, 11, 12, 13, 14, and 15	120	1200 (Type 2)	50	50	120

Note: The test number was marked on the base cloth test component for tracking purposes and prevention of test specimen damage

3.2 Results and Discussion

After each accelerated laundering trial, the test specimens were examined for surface characteristics and visual appearance (shown previously in Table 2) plus visually compared to specimens laundered 25 times under home laundering conditions (see Section 2.2). The results from each accelerated laundering trial determined if changes were required of subsequent trials in order to correlate with home laundering results.

3.2.1 TMET Work Order Number 14294

The first accelerated laundering trial, which evaluated test specimens in accordance with the specifications given in Section 3.1.3.1, produced specimens having three distinctive appearances (see Figure 7). Laundered test specimens from Test Number 1A yielded a gently laundered product that had almost no changes from unlaundered test specimens. Test Number 2A specimens had similar surface characteristics/visual appearance approaching that of home laundered test specimens. Test Number 3A produced harshly laundered test specimens in which the black infrared translucent ink and top coating layers delaminated from the base material, a micro-prismatic retroreflective layer. Although Test Number 2A specimens demonstrated performance capabilities within the surface/visual parameters for home laundering, the laundering temperature was 20 °F less than what is normally used to launder combat uniforms during testing. As a result, additional trials were needed to access test specimen performance when laundered at higher temperatures.

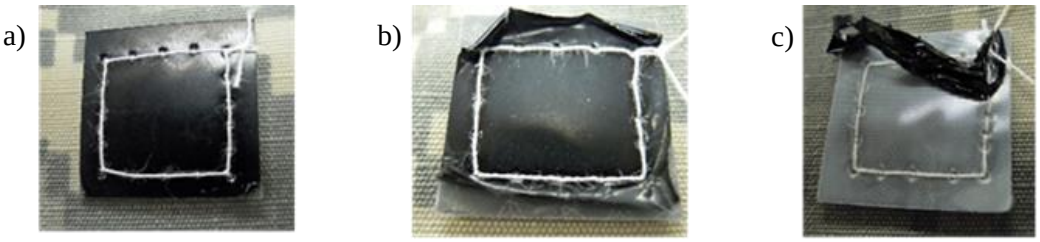


Figure 7. TMET Work Order Number 14294, laundered test specimens after four cycles in accordance with AATCC 61-2013. a) Test 1A; b) Test 2A; c) Test 3A

3.2.2 TMET Work Order Number 14412, Part 1

This trial held the laundering temperature at 140 °F and varied the number of steel balls (see Section 3.1.3.2 for test procedures). Because the IR patch is affixed to military garments, such as the ACU coat, all components (i.e., coat and patch) must be treated as a system during laundering. As a result, additional accelerated laundering trials were warranted to determine the effects in raising the laundering temperature from 120 °F used in AATCC Test Method 61-2013, Test Number 2A to 140 °F used for laboratory testing of ACUs. Besides increasing the laundering temperature, mechanical agitation was also assessed to determine if the scrubbing action from steel balls affected the test specimens in the same manner or to a greater extent when the laundering temperature was increased. The trial was constructed with 4 test groups, each containing a different number of steel balls: 100, 50, 15, and 10. Laundering commenced with Test Number A-140-100, which used test parameters of 140 °F with 100 steel balls. This test produced satisfactory results after each accelerated laundering cycle in which the specimens acquired comparable surface characteristics and visual appearance as those observed in 25 home laundering cycles (see Figures 5 and 8). Because the results of Test Number A-140-100 closely paralleled home laundering outcomes, no further test groups from this trial were evaluated.

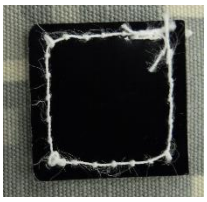
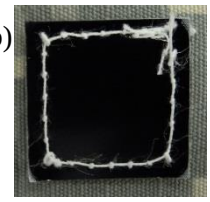
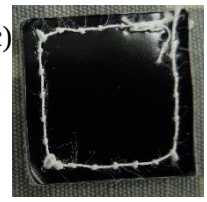
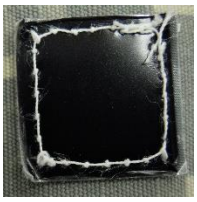
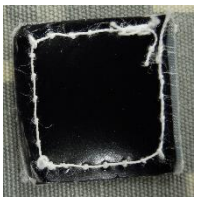
a)  b)  c)  d)  e) 

Figure 8. TMET Work Order Number 14412, Part 1, test specimens after accelerated laundering cycles. a) one cycle; b) two cycles; c) three cycles; d) four cycles; e) five cycles

3.2.3 TMET Work Order Number 14412, Part 2

TMET Work Order Number 14412, Part 2 evaluated the laundering of 15 test specimens, numbered 16 to 30, in accordance with the specifications given in Section 3.1.3.3. The three trial objectives were: 1) measure the coefficient of retroreflection (R_A) prior to laundering to quantify retroreflective performance (coefficient of retroreflection measurements were done at the Defense Logistics Agency-Product Test Center (DLA-PTC)); 2) observe test specimen surface characteristics and visual appearance during the five accelerated laundering cycles (NSRDEC TMET); and 3) measure R_A after laundering to assess retroreflective retention (DLA-PTC). The retroreflective test. Were performed in accordance with paragraphs 4.6.1 and 4.6.3 of CO/PD-06-05A. This non-destructive test does not affect test specimen surface characteristics or visual appearance. Because the main objective for this study was to develop an accelerated laundering test method, the R_A measurements were only taken to follow specification requirements stated in paragraph 4.6.3 of CO/PD-06-05A.

Observations after the first laundering cycle noted slightly more variation in surface characteristics and visual appearance than what had been detected during TMET Work Order Number 14412, Part 1. By the third laundering cycle, test specimens exhibited surface characteristics and visual appearances that were normally seen after five accelerated laundering cycles (see Figures 9a-9c). A few test specimens had the black infrared translucent ink and top coating layers delaminated from the base material along the edges up to the stitching line. As laundering progressed through the fourth and fifth cycles, several test specimens exhibited catastrophic deterioration with up to 50% exposure of the base material (see Figures 9d-9i). Due to the number of unacceptable test specimens after five laundering cycles, the third trial objective, measure R_A after laundering, was cancelled.

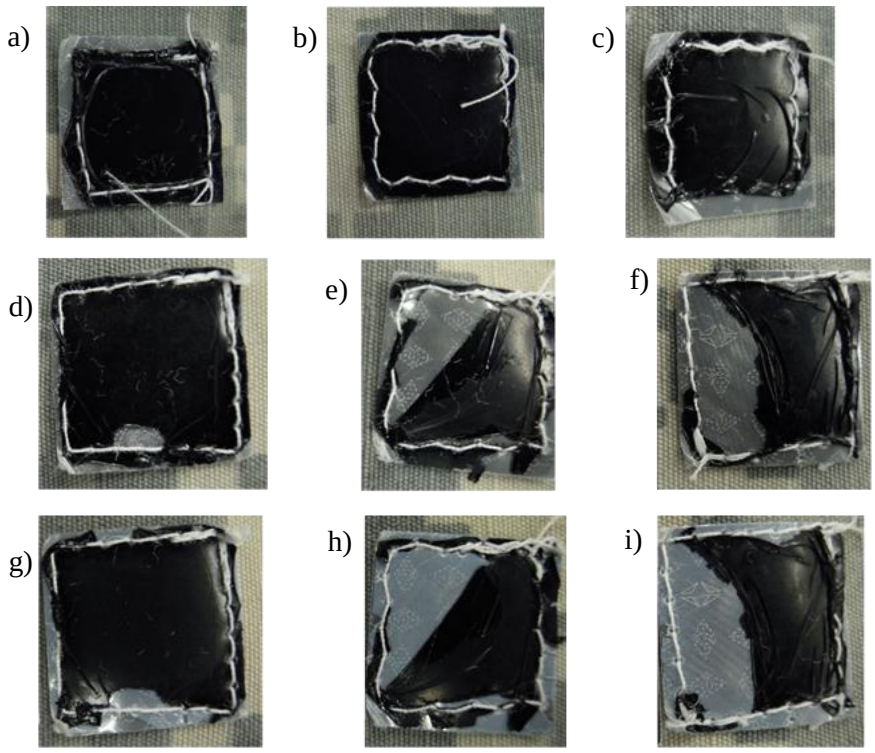


Figure 9. TMET Work Order Number 14412, Part 2, test specimens after three, four, and five accelerated laundering cycles. A) three cycles, Specimen #21; b) three cycles, Specimen #22; c) three cycles, Specimen #24; d) four cycles, Specimen #26; e) four cycles, Specimen #28, f) four cycles, Specimen #30; g) five cycles, Specimen #26; five cycles, Specimen #28; i) five cycles, Specimen #30

3.2.4 TMET Work Order Number 14412, Part 3

Due to extensive specimen deterioration observed in TMET Work Order Number 14412, Part 2, the two objectives for this trial were as follows: 1) examine key test parameters to better understand the laundering interactions; and 2) achieve specimens that meet home laundering surface characteristics and visual appearance. Seven laundering trials were conducted in accordance with the specifications given in Section 3.1.3.4 using four different test parameters: laundering temperature (120 °F or 140 °F), liquid volume (50 mL or 150 mL), number of steel balls (50 or 100), and oven drying temperature (120 °F or 140 °F). Although the liquid volume was set to either 50 mL or 150 mL, the test canister size was held at a constant of 1200 mL to allow the maximum frictional effect of the test specimen against the canister walls.

After one laundering cycle, test specimens in TMET ID groups A through C had the black infrared translucent ink and top coating layers delaminated from the base material along the edges up to the stitching line; groups D thru G maintained test specimen integrity with respect to surface characteristics and visual appearance. Observations after the second laundering cycles noted that test specimens in TMET ID groups A thru C continued to deteriorate to the point some specimens were removed from the trials due to excessive exposure of the base material. Test specimens in groups D, E, and F maintained performance, while test specimens in group G had peeling of the black infrared translucent ink and top coating layers from the base material on one or more corners or on the edges up to the stitching line. After the third laundering cycle, test specimen performance fell into one of three categories: continued deterioration, groups A thru C (see Figure 10); maintained integrity, groups D and E (see Figure 11); and

minor edge peel with loss of surface luster, groups F and G (see Figure 12). The same performance categories were observed after laundering cycles 4 and 5 with degradation of the test specimens continuing at a minor rate.

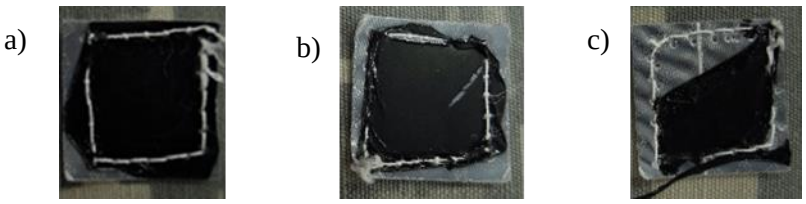


Figure 10. TMET Work Order Number 14412, Part 3, test specimen deterioration, three accelerated laundering cycles of Groups A, B, and C. a) Group A specimen after three accelerated laundering cycles; b) Group B specimen after three accelerated laundering cycles; c) Group C specimen after three accelerated laundering cycles

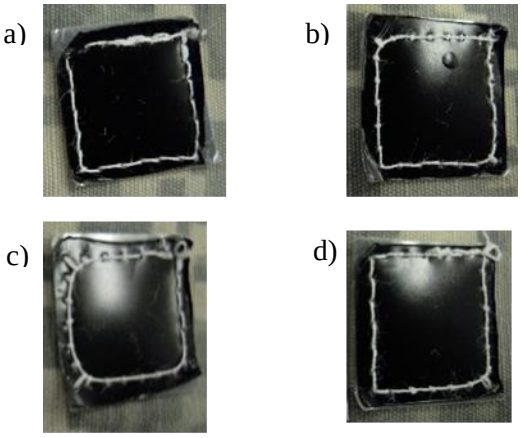


Figure 11. TMET Work Order 14412, Part 3, test specimens maintained integrity, three accelerated laundering cycles of Groups D and E. a) Specimen D1 after three accelerated laundering cycles; b) Specimen D2 after three accelerated laundering cycles; c) Specimen E1 after three accelerated laundering cycles; d) Specimen E2 after three accelerated laundering cycles

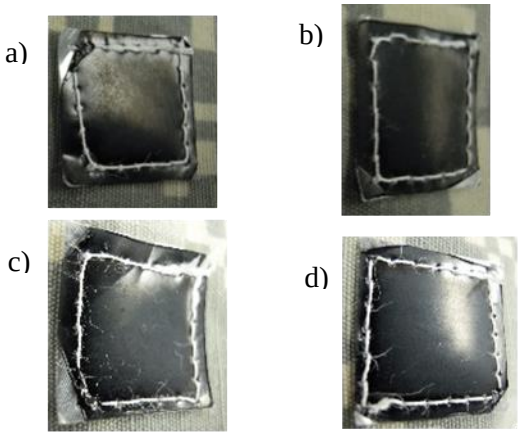


Figure 12. TMET Work Order Number 14412, Part 3, test specimens peeling to stitch line and loss of surface luster, three accelerated laundering cycles of Groups F and G. a) Specimen F1 after three accelerated laundering cycles; b) Specimen F2 after three accelerated laundering cycles; c) Specimen G1 after three accelerated laundering cycles; d) Specimen G2 after three accelerated laundering cycles

Close examination of specimens from TMET ID groups D, E, F, and G disclosed that only three test parameters were varied: laundering temperature (120 °F or 140 °F), liquid volume (50 mL or 150 mL), and number of steel balls (50 or 100). Test specimens in groups D and E were laundered at the higher temperature (140 °F), maintained a constant liquid volume of 50 mL, and varied the number of steel balls by either 50 or 100. In contrast, specimens in groups F and G used the lower laundering temperature (120 °F), retained a higher liquid volume (150 mL), and varied the number of steel balls by either 100 or 50. The core test parameters separating groups D and E from F and G were laundering temperature and liquid volume. At the higher laundering temperature and lower liquid volume, the test specimens maintained the initial surface luster, which was also observed on 25 cycle home laundered test specimens. In comparison, at the lower laundering temperature and higher liquid volume, the test specimen surface became dull with a matte haze. Through examination of test parameters, the liquid volume affected test specimen surface performance. The higher liquid volume created more agitation on the test specimen, thus forming surface modulations from low luster/matte hazing to a "sanded" surface.

3.2.5 TMET Work Order Number 14412, Part 4

The main objective for this accelerated laundering trial was to evaluate the effects of liquid volume on the test specimen. This trial set liquid volume level at 50 mL for test specimens "A1" and "A2" and 150 mL for test specimens "B1" and "B2". In addition to establishing the liquid volume test parameter, this trial also evaluated laundering temperature and number of steel balls. The laundering temperature was set back to 120 °F for three reasons: 1) it is the normal temperature setting for AATCC Test Method 61-2013, test number 2A; 2) independent and government laboratories are accustomed to this temperature setting and will not require equipment adjustment; and 3) Test Number 2A specimens from TMET Work Order Number 14294 retained the low gloss luster at this laundering temperature setting. Because variation in the number of steel balls had minimal to no effect on the previous test specimen outcomes, the steel ball quantity was set at 50 to correspond with AATCC Test Method 61-2013, Test Number 2A. Specimens "A1" and "A2" performed well throughout the 5 accelerated laundering cycles to achieve surface characteristics and visual appearance proficiencies similar to 25 cycle home laundering test specimens (see Figure 13). Because "A1" and "A2" met the criteria using 50 mL liquid volume, specimens "B1" and "B2" were not evaluated.

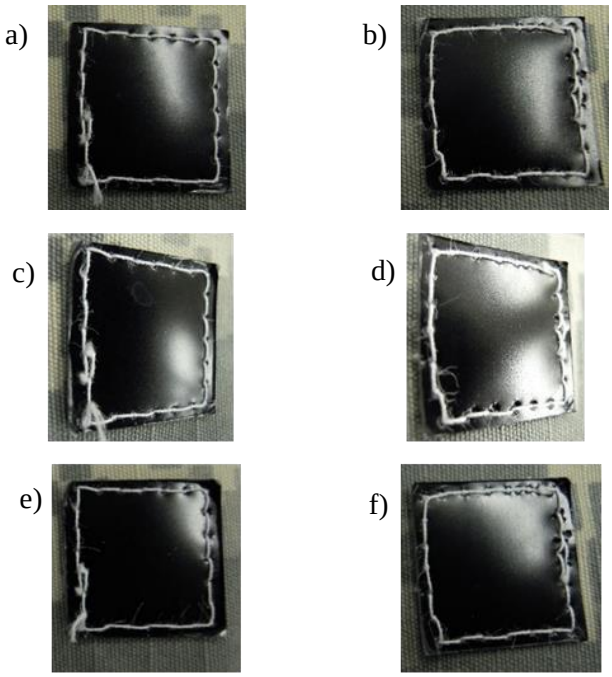


Figure 13. TMET Work Order Number 14412, Part 4, test specimens after one, three, and five accelerated laundering cycles. a) one cycle, specimen "A1"; b) one cycle, specimen "A2"; c) three cycles, specimen "A1"; d) three cycles, specimen "A2"; e) five cycles, specimen "A1"; f) five cycles, specimen "A2"

3.2.6 TMET Work Order Number 14412, Part 5

TMET Work Order Number 14412, Part 5 was conducted to verify that a 50 mL liquid volume for accelerated laundering achieved similar surface characteristics and visual appearance as those observed on 25 cycle home laundered test specimens. This trial was performed in accordance with the specifications given in Section 3.1.3.6. The trial produced surface characteristics and visual appearance for test specimens in "A1-Group 2" and "A2-Group 2". See Figures 14a and 14b, which are similar to both home laundering (see Figure 5) and accelerated laundering TMET Work Order Number 14412, Part 4 test specimens "A1" and "A2" (see Figures 13e and 13f). The test parameters for this Work Order were similar to AATCC Test Method 61-2013, Table I, Test Number 2A procedures except the total liquid volume was set at 50 mL instead of 150 mL.

Figure 14. TMET Work Order Number 14412, Part 5, test specimens after five accelerated laundering cycles. a) specimen "A1-Group 2"; b) Specimen "A2-Group 2"

When the test specimen preparation requirements (Section 3.1.2) are combined with the Table 11 test procedures, accelerated laundering procedures are defined for IR patches.

Table 11. Accelerated laundering: final procedures for IR patches

Base cloth test component size (inches)	Test Specimen location, upper third	Test canister size (mL)	Laundering temperature (°F ± °4)	Liquid volume (mL)	Percent powder detergent of total volume	Number of steel balls	Number of laundering cycles	Oven drying temperature (°F)
2 x 6		1200 (Type 2)	120	50	0.15	50	5	120

3.2.7 TMET Work Order Number 14412, Part 6

TMET Work Order Number 14412, Part 6, laundered 10 specimens numbered 2, 4, 5, 7, 8, 11, 12, 13, 14, and 15 in accordance with the specifications given in Section 3.1.3.7, which were the same procedures outlined in Table 11. These specimens had been tested for R_A prior to laundering. The surface characteristics and visual appearance for these test specimens were similar to both TMET Work Orders 14412, Part 4 and Part 5 and home laundering Section 2.2 (see Figure 15).

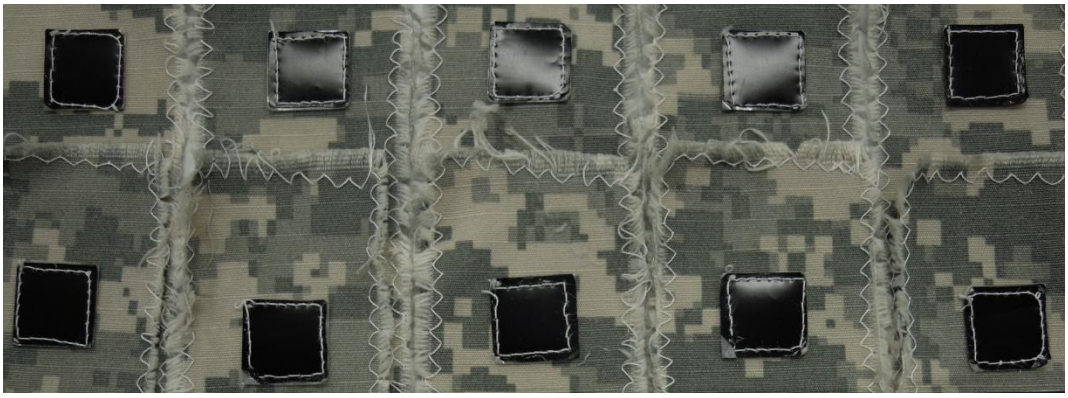


Figure 15. TMET Work Order Number 14412, Part 6, specimens after five accelerated laundering cycles. Top row, left to right: specimens 2, 4, 5, 7, and 8; bottom row, left to right: specimens 11, 12, 13, 14, and 15

4.0 Conclusions and Recommendations

This study performed two tasks, as follows: (1) established a physical specimen baseline for surface characteristic and visual appearance of IR patches after exposure to 25 cycles of home laundering; and (2) developed accelerated laundering test procedures for IR patches. Home laundering was conducted in accordance with CO/PD-06-05A, which used AATCC Test Method 150 and produced test specimens with surface characteristics and visual appearance listed in Table 3 and diagramed in Appendix C. These test specimens exhibited tolerances with respect to base material exposure, creasing/bending without surface breakage, and edge curling in contrast to absolute surface/visual performance requirements stated in the purchase description. The resulting test specimen performance in the areas of surface characteristics and visual appearance established a baseline for 25 cycles of home laundered IR patches.

Once the study established a home laundering baseline for analysis of test specimens, trials were executed in accordance with AATCC Test Method 61-2013, or variations of it, to develop a five cycle accelerated laundering procedure for IR patches in order to reduce laundering time by approximately 80% and lower laundering cost nearly 75%. Test specimen preparation requirements (Section 3.1.2, and Table 11 under TMET Work Order Number 14412, Part 5) established accelerated laundering procedures that produced test specimens which had surface characteristics and visual appearance similar to the home laundering baseline.

The accelerated laundering procedures for IR patches can be defined by three modifications of AATCC Test Method 61-2013, which includes an elimination of some specimen preparation procedures, reduction of liquid volume from 150 mL to 50 mL, and a decrease in the maximum oven drying temperature from 160 °F to 120 °F. These recommended parameters, as also outlined in Table 11, were validated by several other entities. Base cloth swatches with the sewn-on test specimens that were provided to Precision Testing Laboratories, the Navy Clothing and Textile Research Facility (NCTRF) and the Defense Logistics Agency Product Test Center (DLA-PTC). These three entities laundered the samples according to AATCC Test Method 61-2013, Table I, Test Number 2A procedures except the total liquid volume was set at 50 mL instead of 150 mL (Table 11) and visual examination of the samples matched the samples from the TMET laundering tests.

When approval is granted from Product Manager Soldier, Clothing and Individual Equipment (PdM SCIE), IR patch end-item developer and Defense Logistics Agency, Troop Support, specification manager, technical data changes are recommended for CO/PD-06-05A to incorporate accelerated laundering procedures described in Table 11 and detailed in Appendix F.

This document reports research undertaken at the U.S. Army Natick Soldier Research, Development and Engineering Center, Natick, MA, and has been assigned No. NATICK/TR- 17/015 in a series of reports approved for publication.

Appendix A
Home Laundering

Laundering Procedures from Purchase Description, Patch and Brassard, Identification, Infrared Retroreflective, CO/PD-06-05A, dated 10 November 2011:

4.6.3 After launderability (Type I only). Measure the initial coefficient of retroreflection on five (5) test specimens at the perpendicular orientation as specified in 4.6.1. The laundered specimens shall be prepared in accordance with 4.6.3.1 and laundered in accordance with 4.6.3.2. After laundering, re-measure the coefficient of retroreflection for each of the test specimens. If any test specimen fails to retain a minimum of 50 percent of its initial coefficient of retroreflection requirements for home laundering, the sample unit shall be considered a failure.

4.6.3.1 Laundry specimen preparation (Type I only). Five (5) Type I specimens shall be stitched to a cloth prior to laundering 4.6.3.2. Cloth and stitching requirements are listed in Table VII.

TABLE VII. Laundry specimen preparation requirements.

CHARACTERISTIC	REQUIREMENT
Cloth, weight, oz/sq. yd (min)	6.0
Cloth, dimensions, sq. inches	Approximately 2160
Specimen placement	Randomly placed on cloth with a 3-inch minimum from edge
Stitching	Box stitch, 8 (± 1) stitches per inch, standard 301 lockstitch, seam type SSau-4

4.6.3.2 Laundering (Type I only). Type I specimens shall be laundered 25 cycles in accordance with AATCC Test Method 150 using AATCC 1993 Standard Reference Detergent WOB (without optical brightener). Wash, permanent press cycle, 140°F and rinse 80°F, 10 minutes agitation time using 66 grams AATCC detergent without bleach, dry permanent cycle for 40-45 minutes.

4.6.4 Sewability (Type I only). The basic material shall be capable of being sewn per ASTM D 6193 with a standard lockstitch 301 per seam type SSau-4 (boxstitch).

This page intentionally left blank

Appendix B
Home Laundering Observations

Table B-1. Infrared Tools Test Specimens

Laundering Cycle	Observation	Photo Number
0x, Initial	Observed specimen sewn on cloth, MIL-DTL-44436, Class 8 (ACU Universal Camouflage). Specimens sewn in accordance with IR patch specification	
1x	No change in appearance	
2x	Specimen #5, slight bend upwards on one corner	1439
3x	Specimens 4 and 5, slight fold upwards on one corner	
4x	Specimens 4 and 5, slight fold upwards on one corner	
5x	Specimen #1, slight fold upwards on two (2) corners; one corner less than 0.03-inch infrared top coating lifting from base.	1517
8x	Same as 5x laundering observations	
10x	Specimens #3, 4, and 5 lifting on corner; little more bending on corners.	
12x	Specimens #1, 3, 4, and 5 little more bending on corners up to 0.10-inch, very light creasing	
15x	Little more bending on corners, very light creasing, film lifting at corners. Specimen #1 lifting of film along a straight edge.	1647-film lifting on edge, 1659-film lifting on corner
20x	Specimens #1-5, bending on corners, very light creasing, film lifting at corners and on few straight edges, no more than 0.03-inches	1696-slight creasing
25x	Same as 20x with a little heavier creasing	1741-film lifting at corner, 1742-creasing, and 1747-film lifting along edge

Table B-2. CeJay Engineering Test Specimens

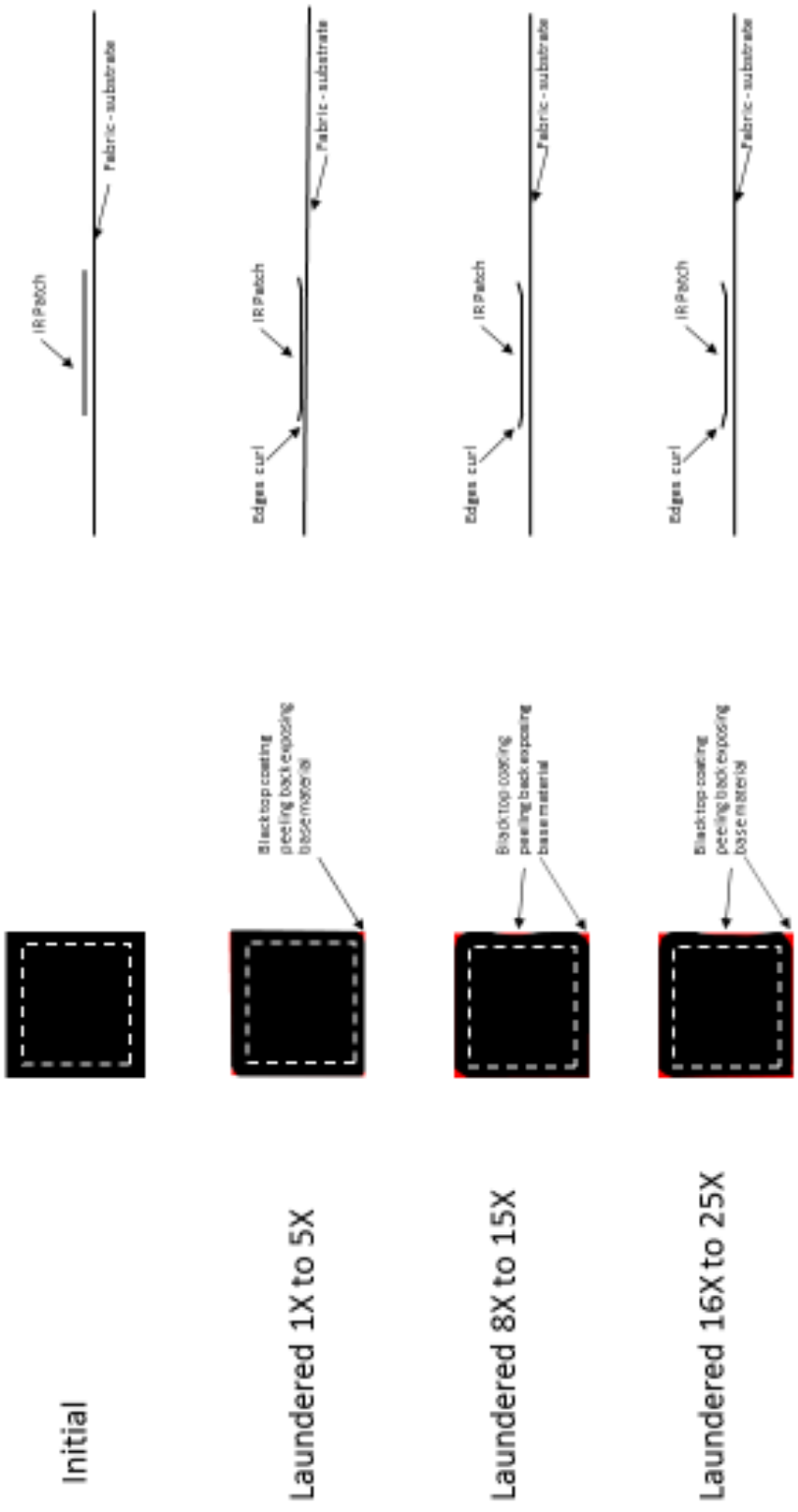
Laundering Cycle	Observation	Photo Number
0x, Initial	Observed CeJay test specimens sewn on cloth panel for any markings or stitching concerns in order to establish reference point. Some test specimens were stitched with uneven tension on the bobbin (lower) thread which allowed the upper thread to be seen as a straight line on the specimen surface. The tension did not affect the test specimens which were securely attached to the cloth panel. All test specimens laid flat on the cloth panel.	1788, #5
1x	Some test specimens exhibited on the corners a slight lifting upwards (curling) from the cloth panel.	1803, #3
2x	Continued to observe test specimen corners slightly lifting upwards from cloth panel.	1826
3x	Specimen #1 on upper corner had black top coating peeling back from base material. Continue to observe all test specimens having some corners slightly lifting upwards from the cloth panel.	1842, 1844
4x	Same observation as 3x.	1871, 1872, 1873
5x	Specimen #1 corners on the upper left and lower right had the black top coating peeling back from the base material. Continue to observe all test specimens having some corners slightly lifting upwards from the cloth panel.	1895
8x	Specimen #1 corners on the upper left and lower right had the black top coating peeling back from the base material were still intact.	
10x	Specimen #1 showed more curling from the cloth panel, especially the upper left and lower right corners. Peeled corner were still intact.	
12x	Same observation as 10x.	
15x	Same observation as 12x.	
20x	Specimen #1 showed more curling from the cloth panel, especially the upper left and lower right corners. Peeled corner were still intact. Approximately 0.01-inch shrinkage of black top coating receding from all edges. Specimen #2 had black top coating peeling from lower edge.	2054, 2055, 2065
25x	Specimen #2 had a little more shrinkage of black top coating from edges.	2095

Table B-3. Infrared Tools Coefficient of Retroreflection (R_A) Test Specimens

Laundering Cycle	Observation	Photo Number
0x, Initial	Prior to sewing on the test specimen, DLA-Product Test Center evaluated IR patches for initial Coefficient of Retroreflection (R_A). Each test specimen was assigned a number to track R_A after laundering. This evaluation randomly selected specimens numbered 1, 3, 6, 9, and 10. All specimens laid flat on cloth panel after stitching. Test specimens # 1 and 10 had a very light imprinted vertical lines within the black top coating Specimen #1 had small needle size dent.	2293, 2294 (vertical imprinted lines) and 2289-needle size dent
1x	Specimens remained flat. Specimen #9, slight crease on upper right side Vertical lines could still be seen on specimens 1 and 10.	2304
5x	Specimens # 1, 6, and 9 had two (2) corners slightly raised from cloth panel Specimens #1 and 6 had some soft creases on the center surface Specimen #10, lower left corner black top coating peeled away exposing approximately 0.03-inches of base material.	2330, 2336
15x	Specimen #3 within the box stitched area had soft creases. Also light curling of lower left and right corners. Specimen #9 had the black top coating peel from the base material along the left edge and upper left corner Specimen #6 curling on three (3) corners plus light creasing.	2354, 2355, 2360, 2362, 2368, 2370
25x	Observations similar to 15x, except specimen curling was slightly greater Creases still present but slightly more pronounced Curling on corners Black top coating peeling on some corners and along some edges.	

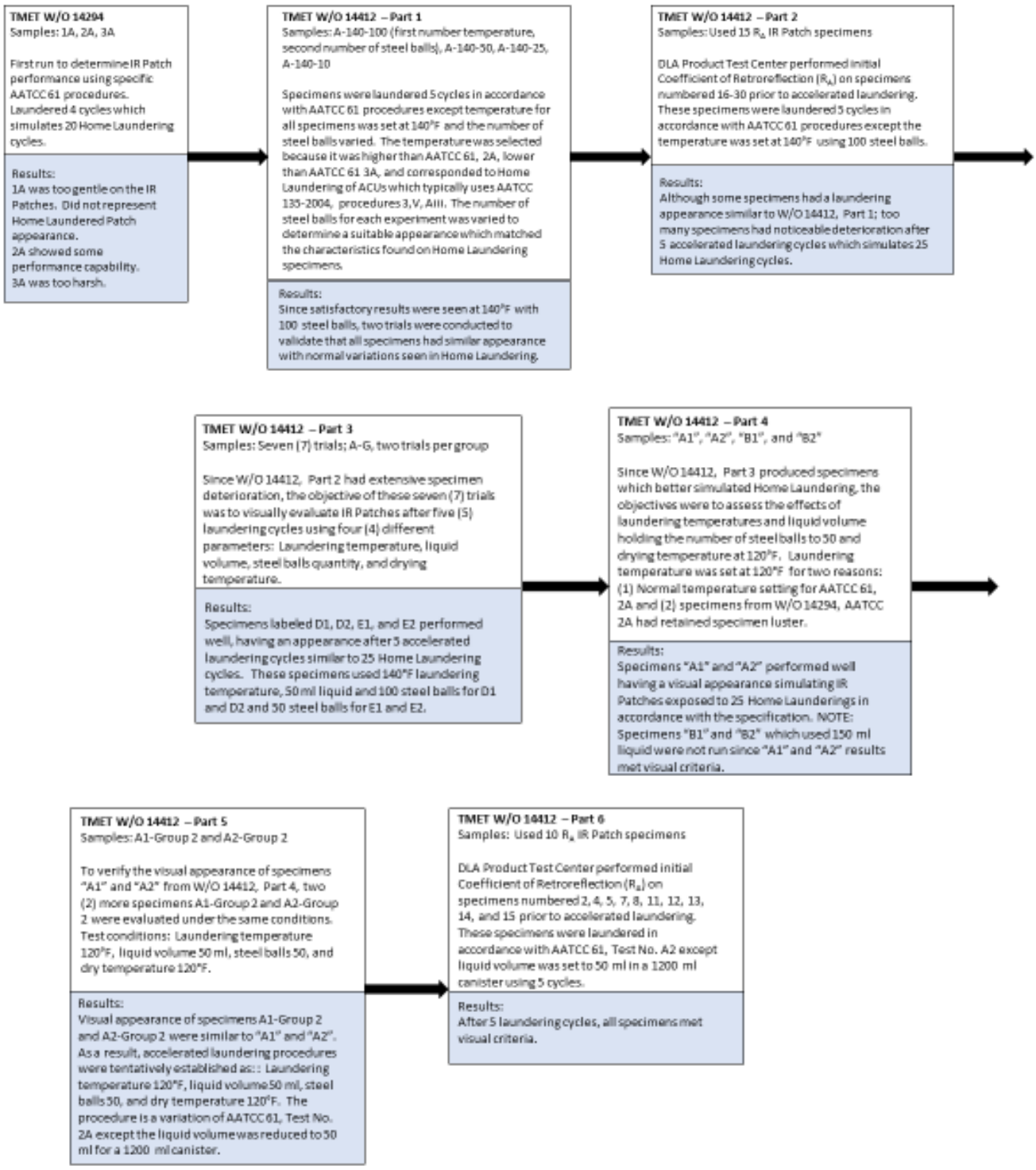
This page intentionally left blank

Appendix C
Home Laundering – Surface Characteristics Baseline



This page intentionally left blank

Appendix D
IR Patch – Accelerated Laundering Sequence



This page intentionally left blank

Appendix E

Table I – Test Conditions of AATCC Test Method 61-2013

Table I—Test Conditions[a]

Test No.[b]	Temp °C (±°2)	Temp °F (±°4)	Total Liquor Volume (mL)	Percent Powder Detergent of Total Volume	Percent Liquid Detergent of Total Volume	Percent Available Chlorine of Total Volume	No. Steel Balls	No. of Rubber Balls	Time (Min)
1A	40	105	200	0.37	0.56	None	10	0	45
1B[c]	31	88	150	0.37	0.56	None	0	10	20
2A	49	120	150	0.15	0.23	None	50	0	45
3A	71	160	50	0.15	0.23	None	100	0	45
4A	71	160	50	0.15	0.23	0.015	100	0	45
5A	49	120	150	0.15	0.23	0.027	50	0	45

[a] Refer to Section 9 for objectives for each test method.
[b] All Tests include an alternate use for 2003 AATCC Standard Liquid Detergent.
[c] Test 1B provides for the use of White Rubber Balls instead of Stainless Steel Balls.

This page intentionally left blank

Appendix F

Proposed Changes to AATCC Test Method 61

Table I—Test Conditions[a]

TMET ID	Test No.[b]	Temp °C (±°2)	Temp °F (±°4)	Total Liquor Volume (mL)	Percent Powder Detergent of Total Volume	Percent Liquid Detergent of Total Volume	Percent Available Chlorine of Total Volume	No. Steel Balls	No. of Rubber Balls	Time (Min)	Oven Drying Temp °F	Number of cycles	Number of Samples
A	NSRDEC	60	140	150	0.15	N/A	None	100	N/A	45	140	5	2
B	NSRDEC-2	60	140	150	0.15	N/A	None	100	N/A	45	120	5	2
C	NSRDEC-3	60	140	150	0.15	N/A	None	50	N/A	45	120	5	2
D	NSRDEC-3A	60	140	50	0.15	N/A	None	100	N/A	45	120	5	2
E	NSRDEC-3B	60	140	50	0.15	N/A	None	50	N/A	45	120	5	2
F	NSRDEC-4	49	120	150	0.15	N/A	None	100	N/A	45	120	5	2
G	AATCC 61, Test No. 2A	49	120	150	0.15	N/A	None	50	N/A	45		5	2

- Pink box represents changes from previous line
- Tan box represents laundry temperature change
- Use TMET Work Order Number 14294 to obtain drying method. If not available, then use 120°F